Task 4, Higgs to gammatautau

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Introduction

- Step 1 – simulate pp collision at LHC, simulate ggF Higgs production.
- Done with powheg box, produces lhe file as output.
- With Pythia8, we use the lhe file from previous step as output.
- Decay Higgs boson and everything else in the event, according to the SM.
- Can suppress/enhance specific BRs, e.g. 100% $h \to \tau_{had}\tau_{had}\gamma$.
- For now consider only Higgs 3 body decay and $h \to Z(\tau\tau)\gamma$.

Cuts

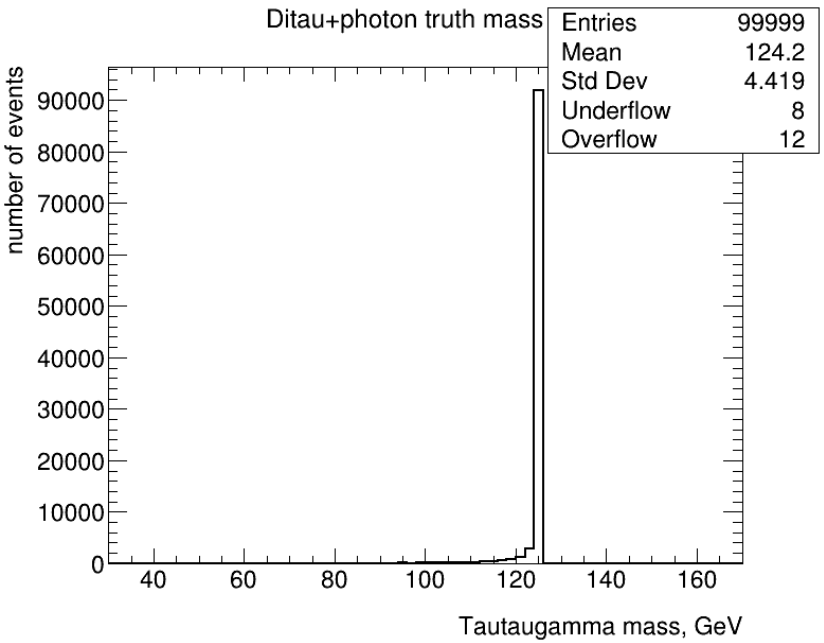
- In principle don't apply any cuts, but...
- Pythia needs to match lhe files created by powheg to shower.
- Need to avoid infrared and collinear divergences.
- If we want to simulate something practical with Delphes we need to require minimal pT and dR of taus and photon.
- These are not in Higgs rest frame.

Good News

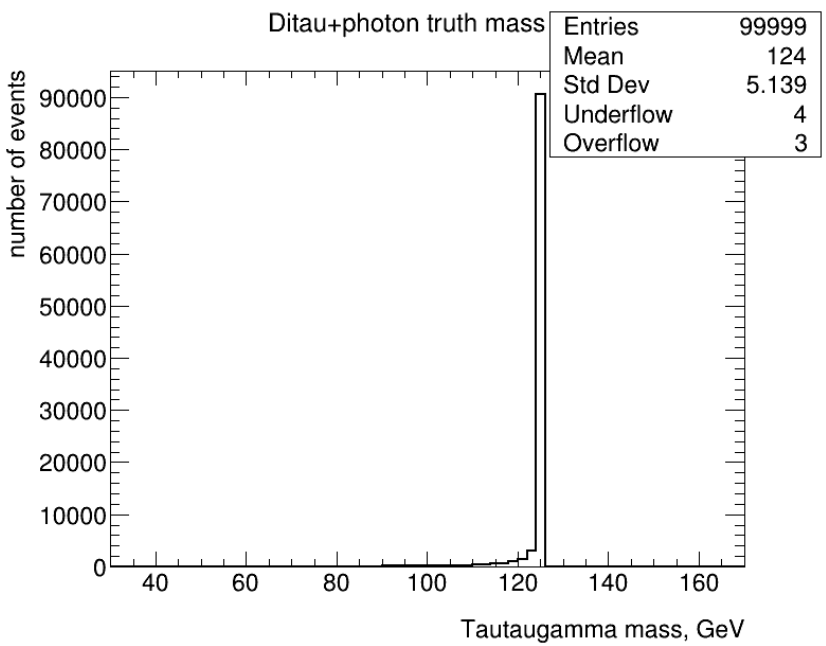
- At truth level, we can boost to Higgs rest frame and apply whatever cut we want.
- Of course, need to make sure that our reco cuts cover whatever changes this causes.
- By the way, maybe $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$ is better to cut on than in degrees?

True $\tau\tau\gamma$ inv mass

$h \to \tau\tau\gamma$

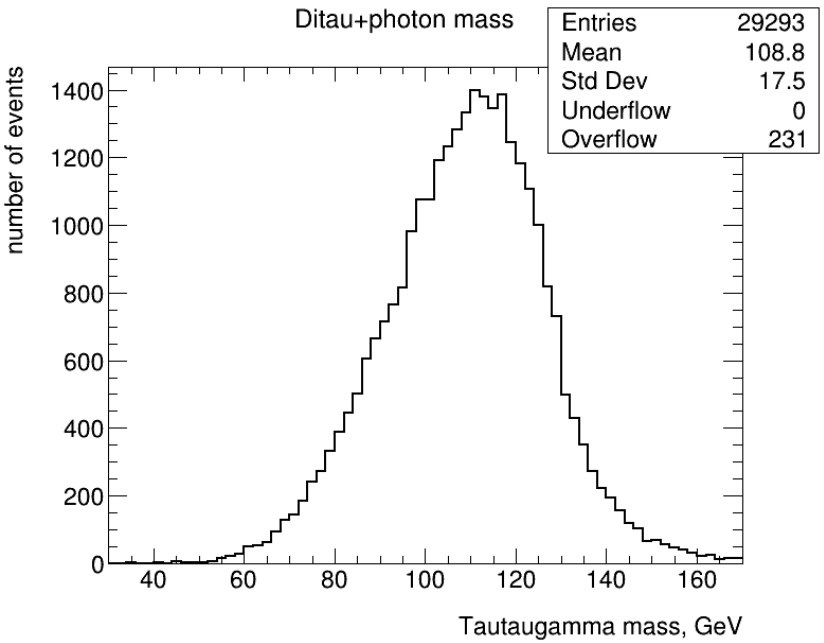


$h \to Z(\tau\tau)\gamma$



Visible $\tau\tau\gamma$ inv mass

$h \to \tau\tau\gamma$



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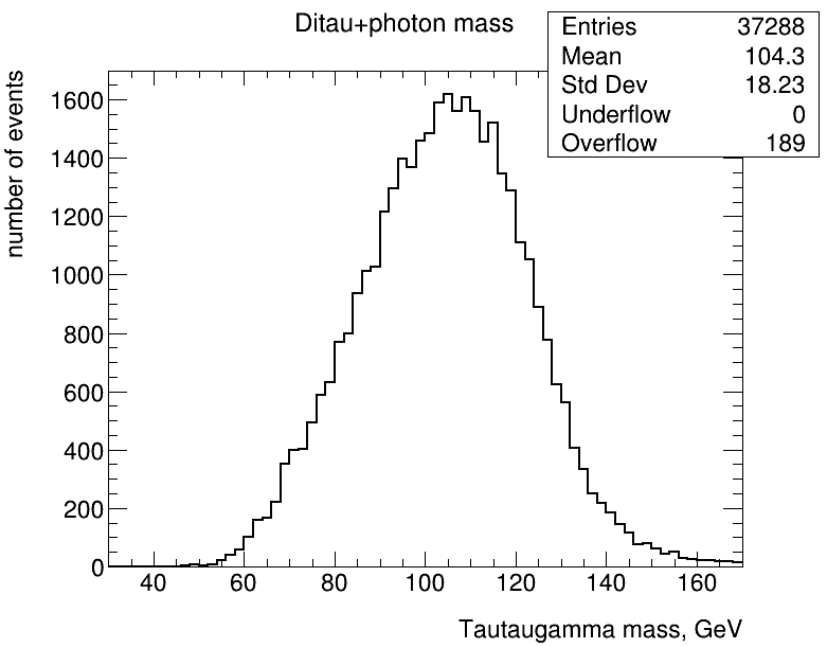
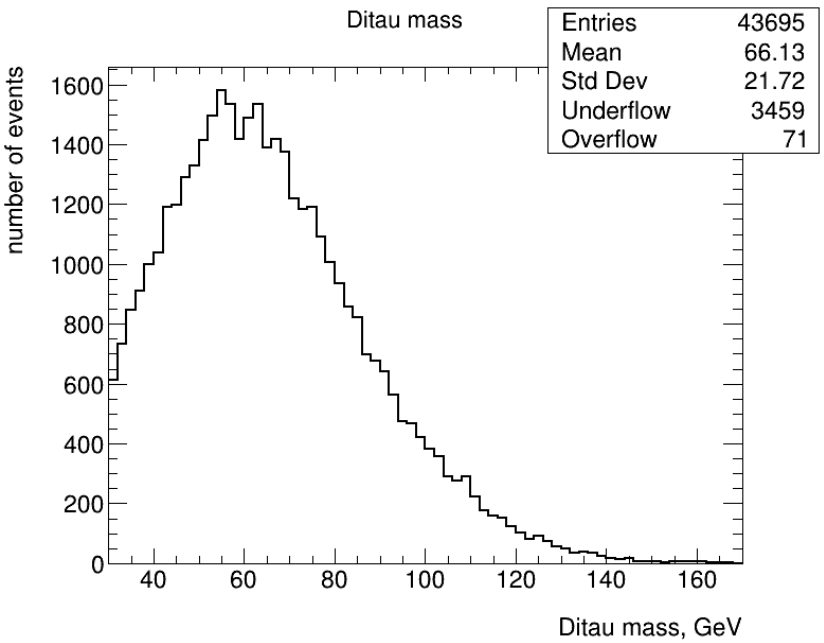


Visible $\tau\tau$ inv mass

$h \to \tau\tau\gamma$



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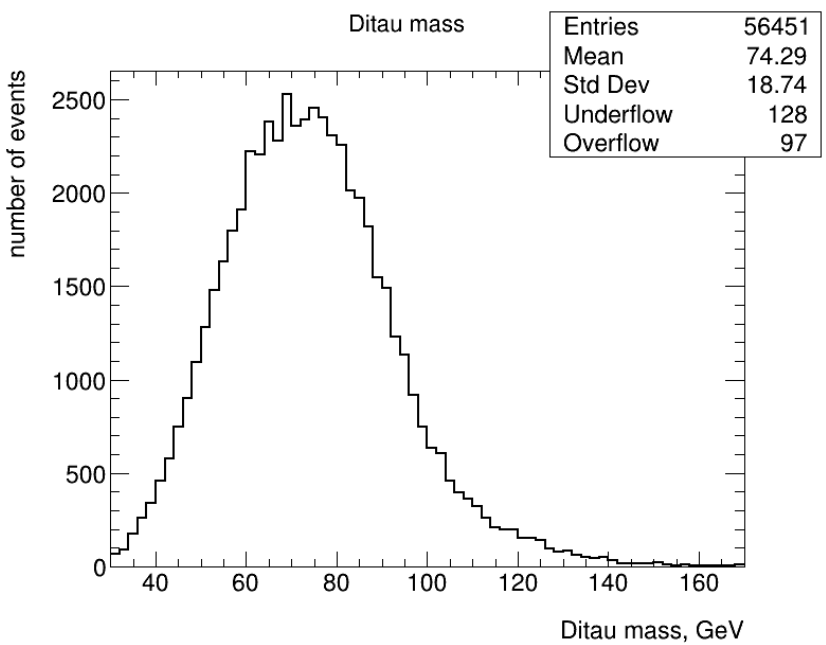
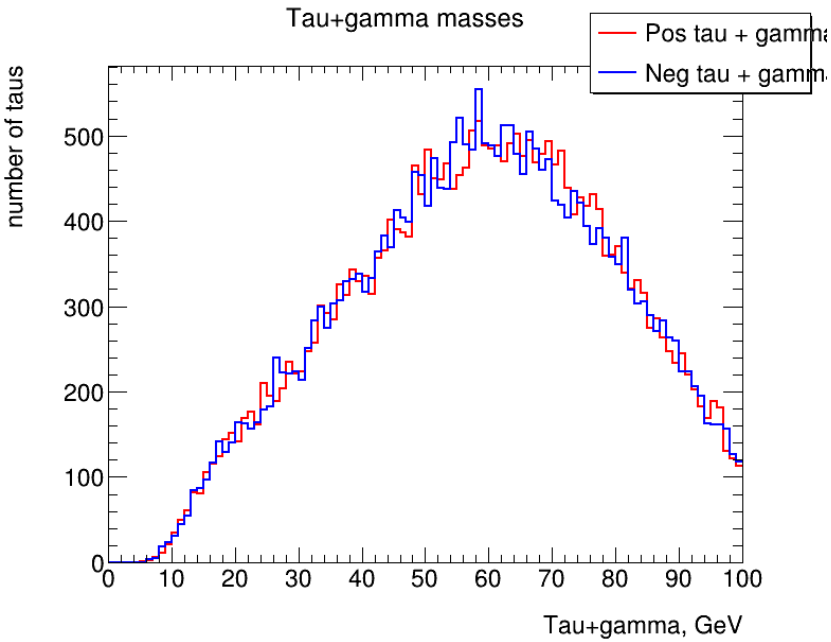


Visible $\tau\gamma$ inv mass

$h \to \tau\tau\gamma$



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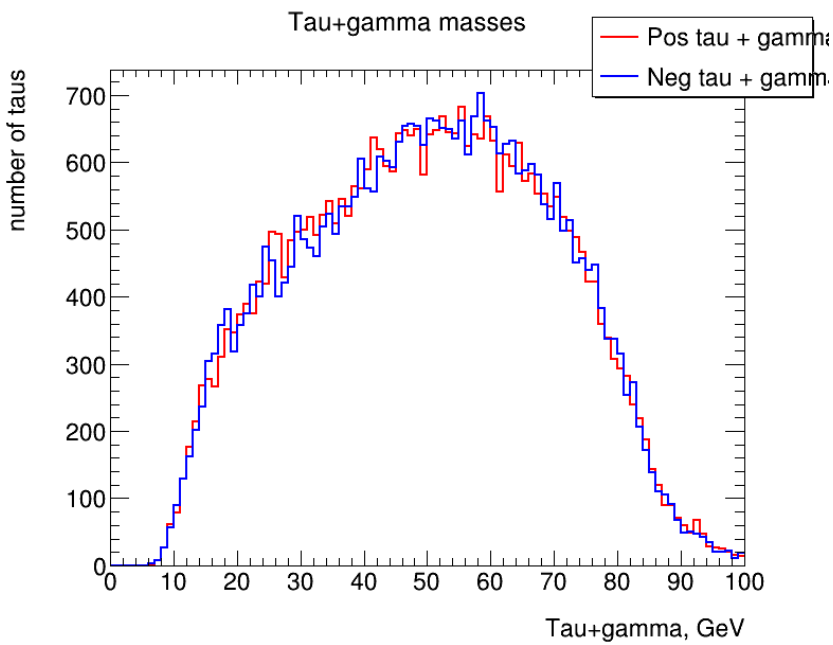

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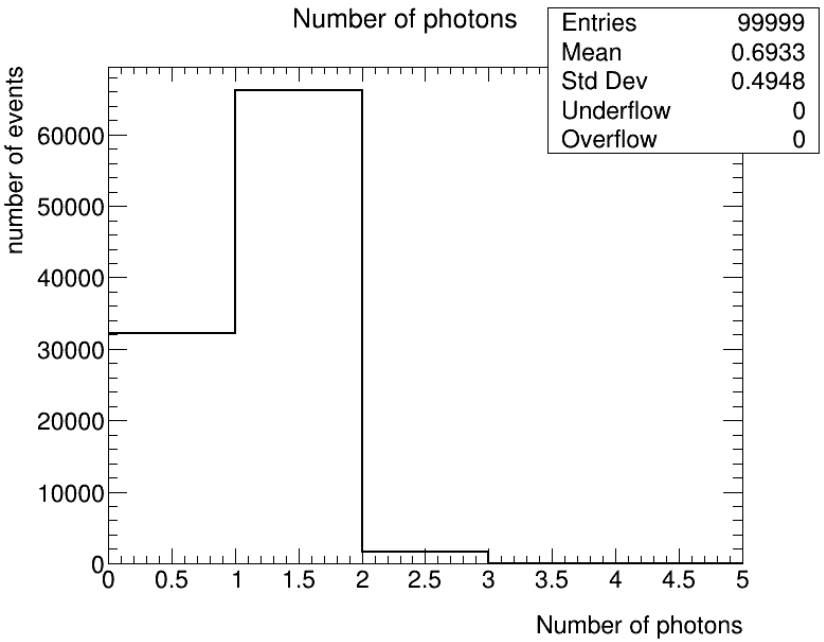

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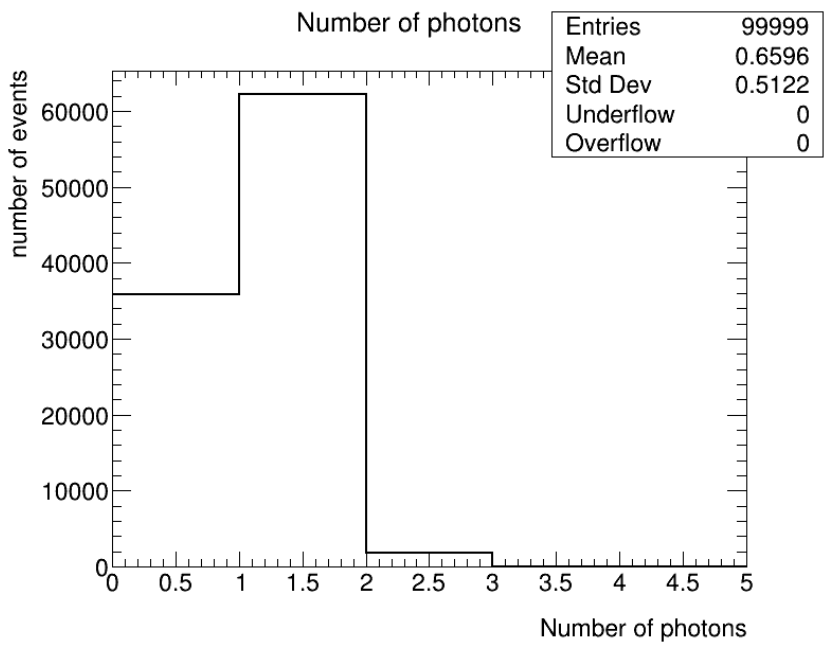

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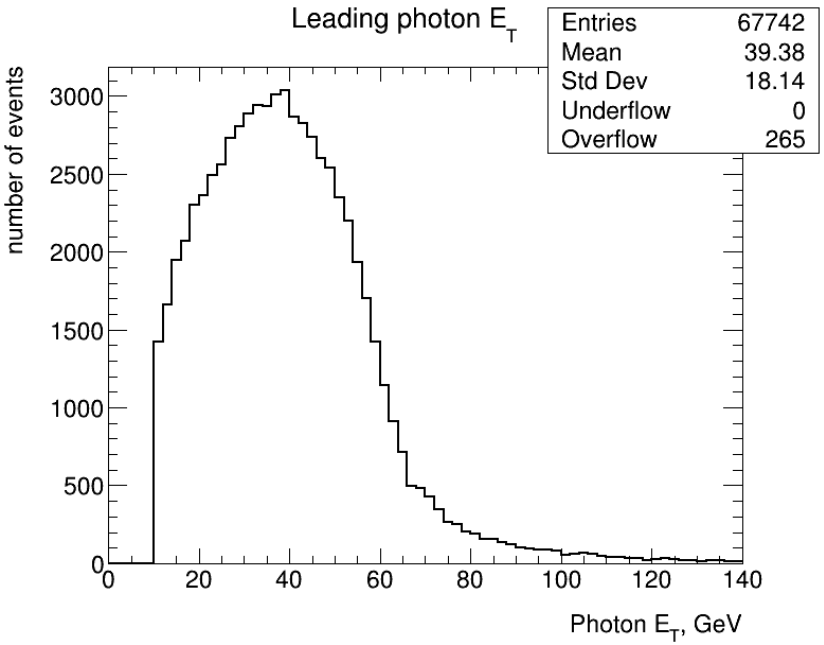

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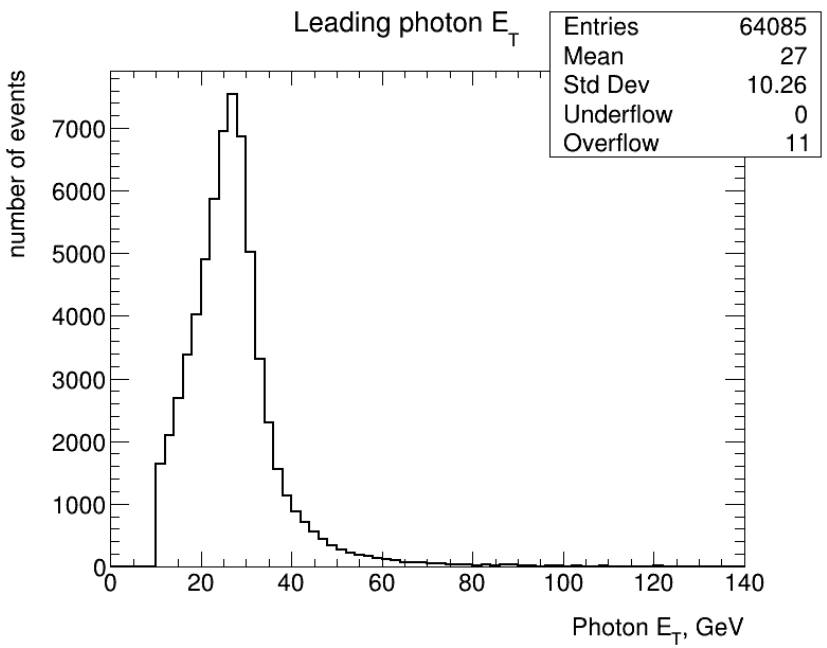

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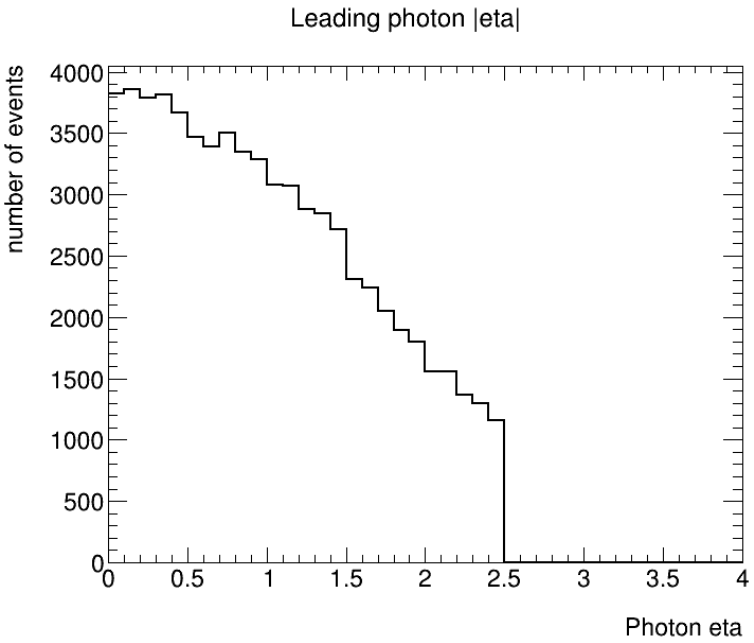

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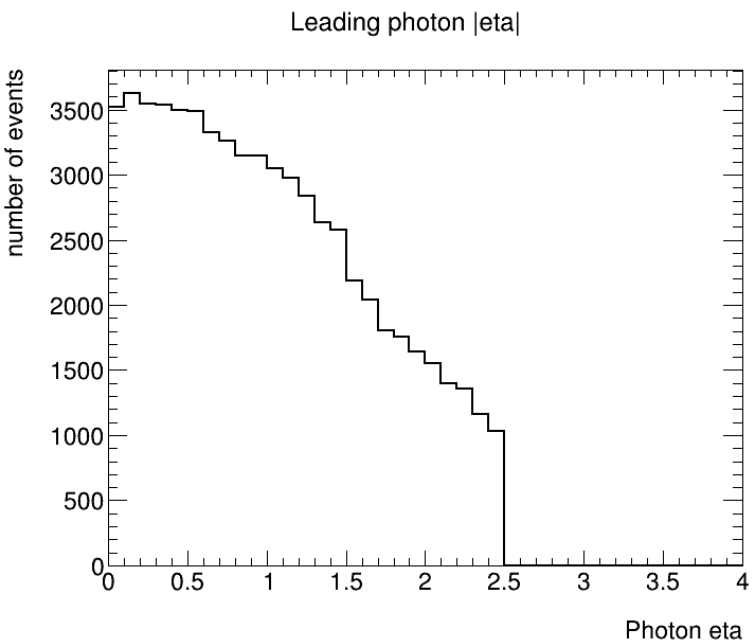

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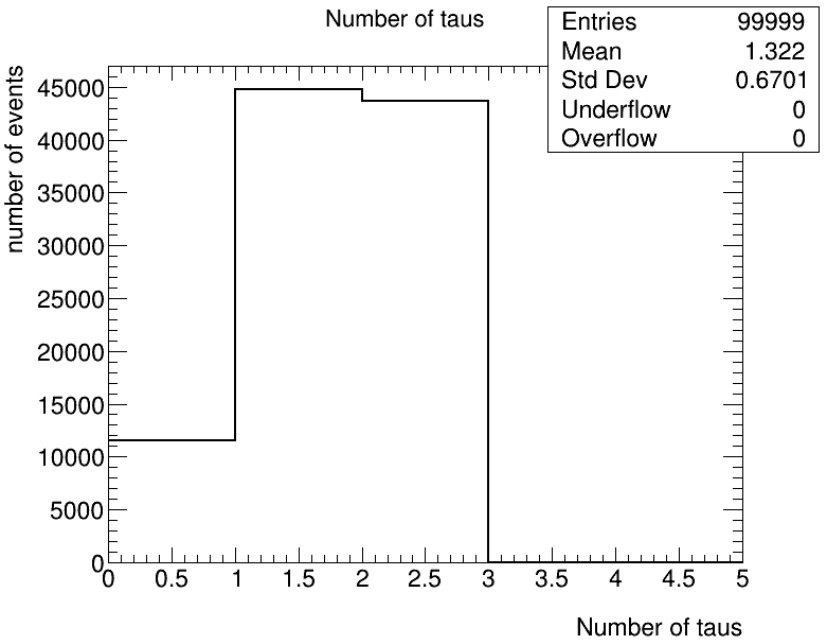

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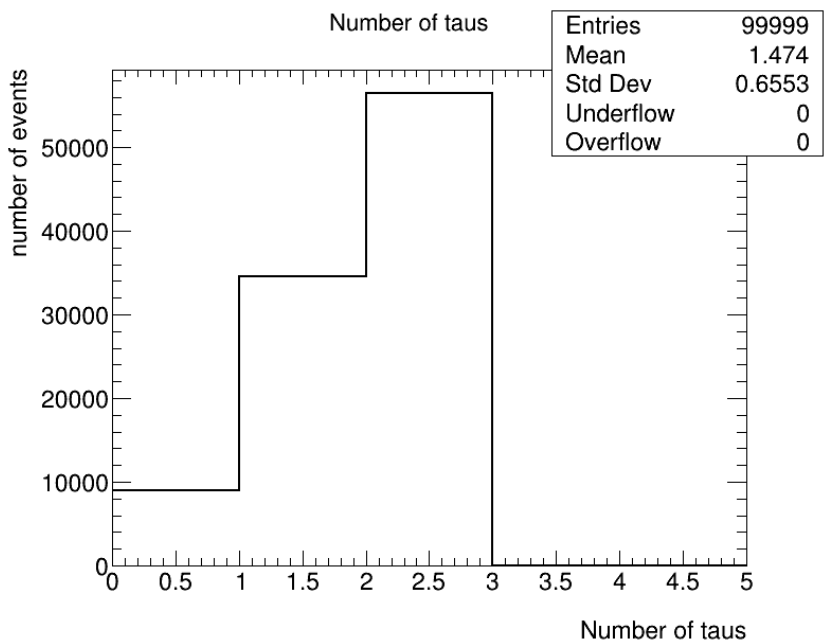

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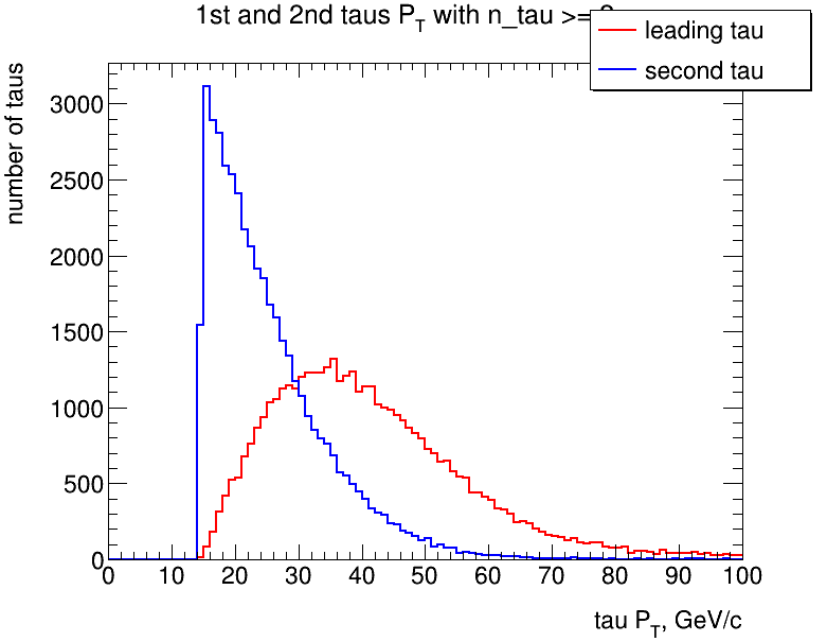

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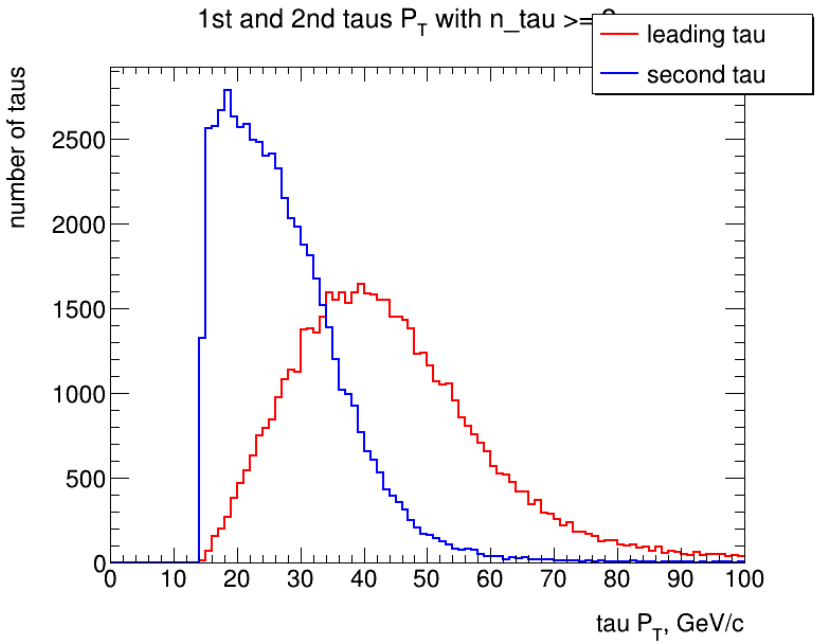


Overall Idea

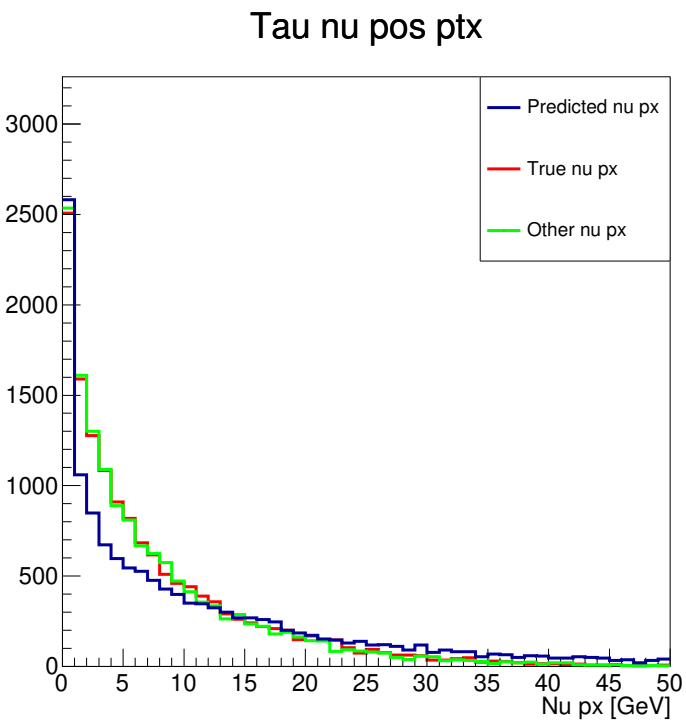
- We know how to produce SM $h \to \gamma\tau\tau$, resonant and non-resonant.
- What we do is an approximation, not including all possible Feynman diagrams.
- Also – don't have the BSM interference in Pythia, and the reso/non-reso events are produced separately.
- So we need weights and cross-sections to know how different from SM we are based on b_τ.

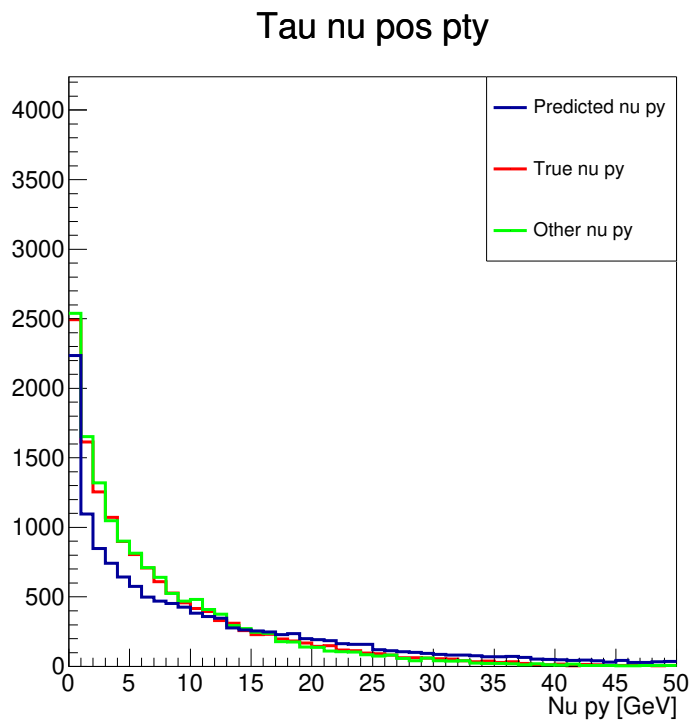
Something Different

Stransverse mass mT2

- Proper description etc
- Idea – distribute missing transverse momentum between two invisible particles.
- Takes 2 tau 3-vectors and MET, returns tau neutrinos kinematics.
- Limitations – only gives us information in the transverse plane.
- Limitation v2 – works great if MET is only coming from taus. Once experimental smearing is added, things get a bit harder.
- Test – run mT2 with reco taus, compare with true tau neutrinos

Some mT2 plots





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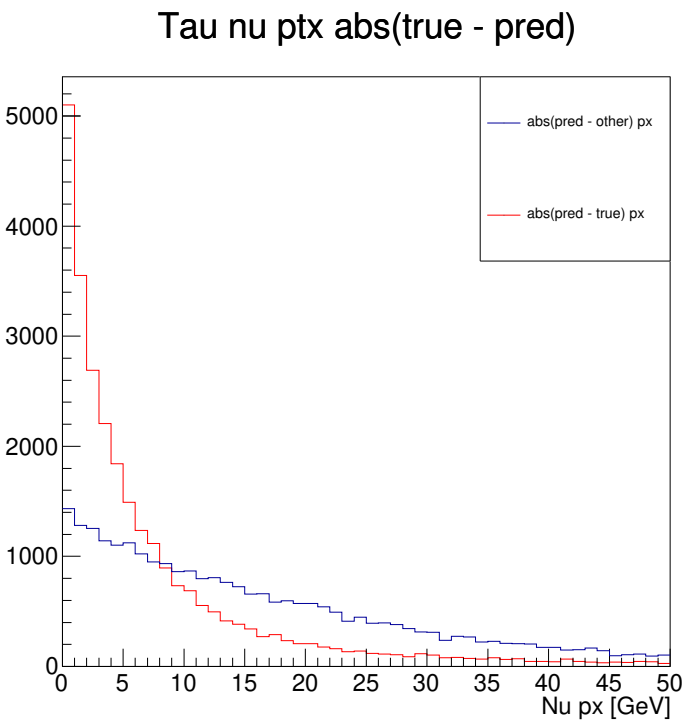
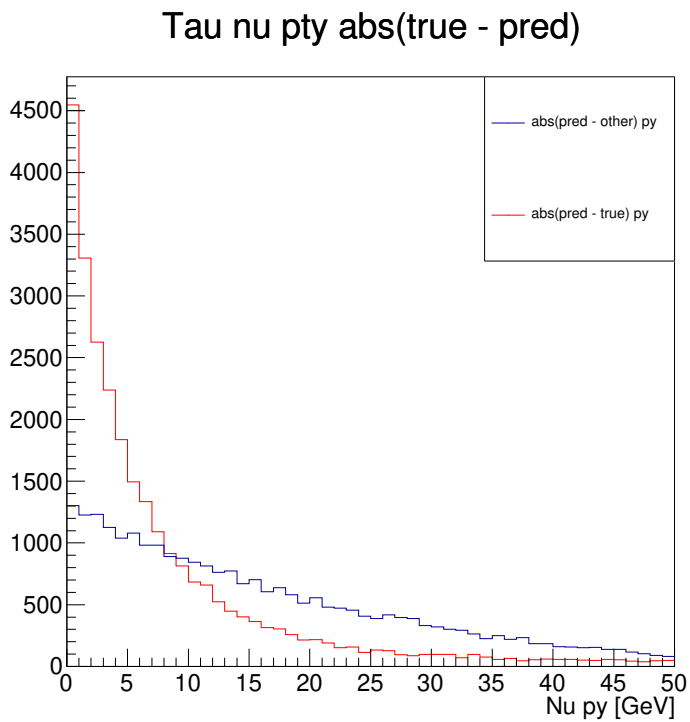
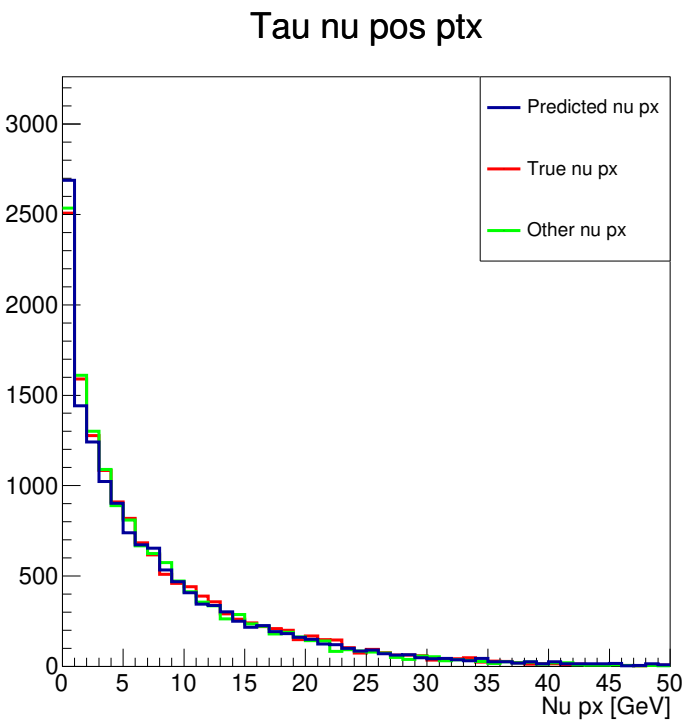


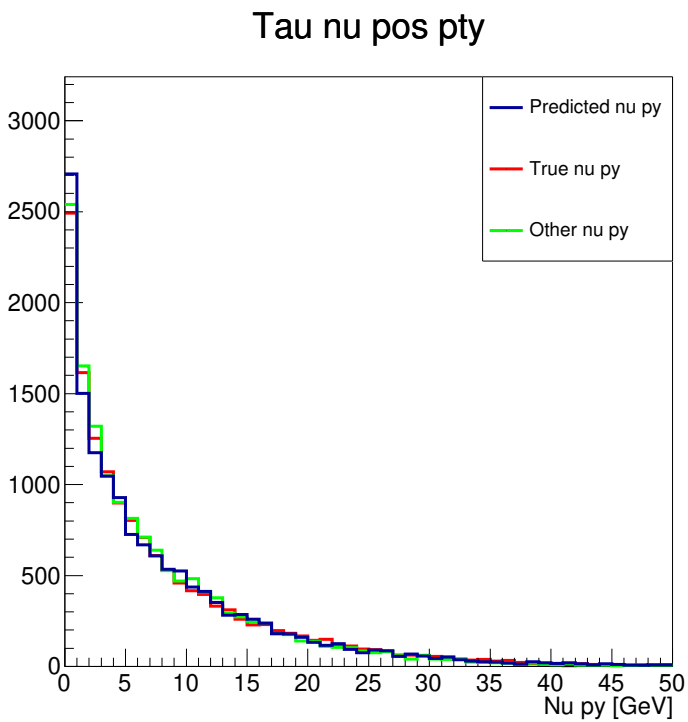


Comments

- Looks ok, but pX-pY are asymmetric, this seems to be Delphes issue, investigating.
- Keep in mind, MET gets contributions from energy mismearusements, not just from neutrinos
- In fact, if we use $\nu_1 + \nu_2$ as MET, get a much cleaner result.
- So the conclusion is that the method works reasonably.

Some mT2 plots





Some mT2 plots